First steps to modifying human-elephant relationships in a conflict-prone Alur-Sakleshpur-Kodlipet region of Karnataka

FINAL REPORT

AUGUST 2019

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Executive summary

Human-elephant conflict has been one of the challenging conservation issues across Africa and Asia. Asian elephant (*Elephas maximus*) has been widely distributed outside PAs into human-dominate landscapes in Asia, leading intense conflicts between people and elephants. Hence, there is a need to find out locally applicable conflict mitigation mechanisms that would enhance conservation of elephants and conflict resolution in altered landscapes. The study was carried out between 2015-2019 in a contested land-use mosaic of Alur-Sakleshpur-Kodlipet region, home to 40 elephants and 1,00,000 people in Hassan-Madikeri forest divisions in Karnataka. We tracked elephants on daily basis and monitored their movements and conflict with people. Based on this information, in collaboration and cooperation with Karnataka Forest Department, early warning systems using bulk SMS, voice call alerts to people mobile phones indicating elephant locations, installation of GSM based digital display boards, and alert beacons in critical junctions along identified roads in the region. We have also monitored the efficacy of early warning systems on incidents of human deaths due to elephants. Due to presence of solar powered electric fences around large coffee estates in the central part of the landscape resulted in the shift in elephant intensive areas of use of villages from north-south direction in 2015-16 to north and northeast parts in 2016-18 in the study region. This restriction of elephant movements resulted in increased incidents of crop damages in the north and northeast parts of the study region. Hence, we suggest, fencing large areas should be discouraged or create openings along fences based on elephants need to be taken up to reduce incidents of crop damage incidents. Most of the crop damage incidents occurred between August-January, denoting the peak conflict season coinciding with paddy growing period. Percentage of crop damage by elephants during this peak increased over years with a corresponding decrease during non-paddy season months between February - July. The reduced crop damage incidents during non-paddy season months could largely attributed to positive steps of 'no chasings' strategy adopted by coffee planters and presence of Rapid Response Teams of the Karnataka Forest Department enhanced no disturbance to elephants. Since, human deaths were mostly accidental in nature, sending out alerts in the form of text messages and call alerts and display of elephant information on digital display boards have been well regarded by local community, Consistent efforts by rapid response teams coupled with timely intimation of elephant presence using early warning systems helped reduce human death incidents from an average of 4-5 people per year between 2010-17 to two persons/year between 2018-19. The study suggests, there is a strong need to shift from reactive problem animal approach to problem location approach to enhance safety to people and property in altered landscapes.

INTRODUCTION

Conservation of large mammals, particularly elephants, outside protected areas is increasingly becoming a challenge for park managers, scientific and conservation organizations, and local communities due to pressures associated with anthropogenic habitats and compel coexistence with humans (Sitati and Walpole 2006, Graham *et al* 2010, Fernando *et al* 2012, Gubbi, 2012). Continuous degradation and conversion of natural habitats, encroachment, and developmental activities posed a great threat to elephant survival in altered landscapes, leading to intense conflicts across Africa and Asia (Sukumar 1994, Sitati *et al* 2003, Chartier *et al* 2012). Effects of these threats, though not clearly documented, few studies (Ahlering *et al* 2011 & 2013, Burke *et al.* 2008, Vijayakrishnan *et al* 2018) reported that human induced pressures increase stress levels in elephants and may affect their viability of population survival in human modified landscapes.

Asian elephant (*Elephas maximus*), recently recognized as a National Heritage animal by the Government of India, around two third of its population lives in non-protected areas either close to or within human dominated landscapes, creating opportunities for greater contact and conflict (Sukumar 1989, Fernando *et al* 2019). Human-elephant conflict escalated with ever increasing human population coupled with hydro-electric projects, agriculture expansion, transportation networks and reservoirs within forested elephant habitats, resulted in fragmented populations (Leimgruber *et al* 2003) and pushed these pachyderms into neighbouring human use areas (Desai 1991). Asian elephant worshiped as God, occupies cultural and religious prominence in Asian societies, positively impacting peoples' acceptance of the species as a part of their landscape . However, this sentiment is rapidly eroding as a result of human-elephant conflict. Thus, conflict resolution is not only of scientific and conservation importance but a societal need to retain traditional/cultural values of tolerance in human-elephant relationships.

There have been various techniques employed to deal with human-elephant conflicts in interspersing areas of elephants and people. Multiple methods of deterring elephants from human-use areas or crop lands by deploying physical barriers such as electric fences, elephant proof trenches etc., traditional methods of using crackers, use of tobacco – chilly rope, elephant drives etc., have showed mixed results in their efficacy in dealing with human-elephant conflict (Nath and Sukumar 1998, Parker and Osborn, 2006, Kioko *et al* 2008, Chelliah *et al* 2010). Recently, numerous experimental trials focusing on innovative measures have showed varying degrees of success to mitigate human-elephant conflict in Asia and Africa (King *et al* 2011, Davies *et al* 2011).

Of the various kinds of conflict mitigation techniques, early warning systems proved to be effective in reducing incidence of conflicts (Venkatraman *et al* 2005, Hedges and Gunaryadi 2009, Davies *et al* 2011, Sugumar and Jayaparvathy 2013). However, there have been very few studies which addressed long term monitoring of the efficacy of mitigation techniques in terms of reduction

in conflicts, adoptability of techniques by local communities, reduced stress levels in people, increased peoples' tolerance towards elephants, and sustainability of conflict mitigation measures.

Here, we report, the movement of elephants and their conflict with people between 2015 - 2019,while analyzing efficacy of early warning systems in promoting human-elephant coexistence (2017-19). The objectives are as follows:

1. Understanding distribution patterns of elephants in the coffee-paddy dominated Hassan region
2. Spatial and temporal patterns of human-elephant conflict
3. Efficacy and impact of human-elephant conflict mitigation mechanisms.

MATERIALS AND METHODS

A. Study area

The Alur-Sakleshpur-Yeslur-Kodlipet region in the Hassan-Madikeri forest divisions is primarily dominated by coffee-paddy plantations interspersing with monoculture refuges such as Acacia, Eucalyptus, and abandoned coffee, and few Reserved Forest fragments ,across 220 villages, covering 620 km². The region has been home to around 40 elephants and supporting 1,00,000 people. Human-elephant conflict has been intense in the study region with crop damages and loss of lives over decades. This resulted in trauma, fear, and antagonism in local communities towards elephants in the region. Physical barriers such as solar powered electric fences and trenches have been widely implemented to reduce conflicts but they failed to yield desirable positive results. With elephants and people interacting with each other on daily basis, safety to human lives and crops has been a major challenge in the region. As result of intense conflicts, state forest department has been forced to capture elephants on a regular basis.

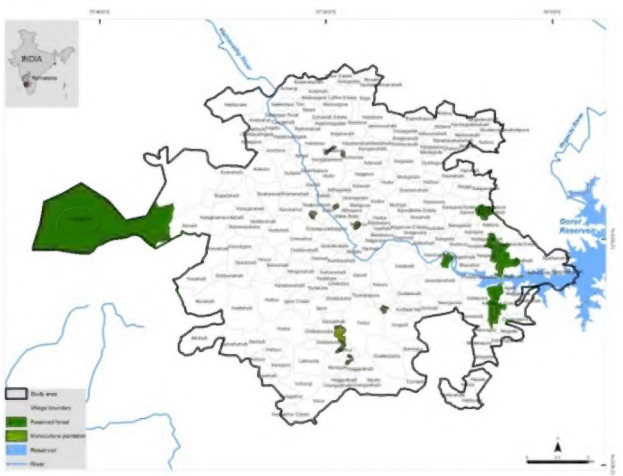

Figure 1.Map of Alur-Sakleshpur-Yeslur-Kodlipet region with Reserved Forests (dark green), monoculture refugees (light green), and villages

B. Methods

The following methods have been implemented in cooperation with the Karnataka Forest Department field staff, Hassan Forest Division.

- ***Monitoring elephant movements and conflict occurrence***

Daily tracking of elephants in coffee plantations, monoculture refugees, and villages was carried out to locate elephant presence during the day for three years (Year 1: March 2015 -April 2016; Year 2: October 2016-September 2017; Year 3: October 2017 - September 2018). We have recorded information on date, time, identity of elephant herd, herd composition, incidence of conflicts, type of habitat, and their movements with handheld GPS (Kumar *et al* 2010). We have also obtained information *from Ra*pid Response Teams of Hassan Forest Division and local informants about elephant presence. This information has been used to alert people in advance about elephant movements using early warning systems. We have also analysed location information to identify intensity of use of villages by elephants for the period between March 2015 - February 2016 (Year 1), October 2016 - September 2017 (Year 2), and October 2017-September 2018 (Year 3). Similarly, to understand spatial distribution and intensity of conflicts, we have analysed crop damage incidents per unit area across villages and interpreted it in relation to the intensity of elephants' use of villages for the same period as indicated above. However, to understand seasonal variations in occurrence of crop damage by elephants, we have used information between March 2015-2016 (Year 1), March 2017-February 2018 (Year 2), and March 2018 - February 2019 (Year 3). For human death incidents, we have used information from forest department records and during our study since 2015.

Early warning systems

We have initiated early warning systems in cooperation with the Karnataka Forest Department to alert people of elephant presence in three ways:

- **SMS and out bound voice call services**

A database of around 2700 mobile phone numbers of local residents (2650 men and 50 women) who voluntarily shared to receive alerts over phone has been maintained. This database include information on. name of the person, place of residence, division, estate etc., covering 45,000 people living in 152 villages in the study region.

Figure
indicating elephant location

On a daily basis, elephant presence information has been sent out in the form of text messages and call alerts to peoples' mobile phones in Kannada (Figure 2). Daily alert messages or calls include information on location of elephants and name of the coffee estate/village along with a contact number, in case of any emergency help required, to people residing within 2 km from the place of elephants. These messages or calls cover farmers, daily wage workers, business people, and members of Rapid Response Teams of the forest department. We have used GUPSHUP enterprises, a web based platform and Google translate to send out text messages and calls and monitored delivery of messages or calls based on daily reports. Responses from people for Bulk SMS

and call alert initiatives have been systematically recorded, grouped, and analyzed for their efficacy (Kumar and Ganesh 2014).

- **GSM based Digital display boards and alert beacons**

GSM-based digital display boards and mobile operated elephant alert beacons have been installed in critical locations along the identified sensitive roads (Figure 3). There are seven digital display boards and eight alert beacons, directly benefitting 45,000 people living in 110 villages. While, Karnataka Forest Department has also installed five boards, benefitting 11,800 people living in 29 villages. Using web-based interface program, elephant location information has been sent out to display boards. Information has been displayed as a 'scroll /ticker' in Kannada language. For each alert beacon, at least two peoples' mobile phone numbers from the nearest village have been registered. These people are authorized to operate alert indicators in case of elephant presence within 1 km distance from the light. Information received in the form of SMS from alert indicators, when operated, was systematically recorded to understand involvement of people in alerting residents of respective localities about elephant presence.

Figure 3.GSM-based digital display board alerting people of elephant presence.

- **Efficacy and impact of early warning systems**

Effectiveness of early warning systems has been carried out by analysing response calls received from people between March 2015 - February 2016, October 2016-March 2019 to SMS and alert call systems, operations of alert beacons by local community, and number of messages sent to digital display boards. We have compared number of human fatal incidents and time taken between incidents of fatalities against baselines.

RESULTS

1. Elephant distribution and use

Elephant were seen throughout the year using different habitats in the study area. During the last three years, around 40 elephants, with 13 adult males, 13adults females, two sub adults. four juveniles, and nine calves moved across the habitat mosaic of the study region. It was observed that elephants locations were distributed in north-south direction during the year 1 (2015-16) with varying intensity of use of villages, but their distribution and intensity of use of villages was highly restricted towards north and north east in year 2 and year 3 (2016-17 and 2017-18, respectively; Figure 4). Mean intensity of elephant locations across villages increased from year 1 (0.67±0.11) to year 2 (1.64±0.41) and in year 3 (1.60±0.24) across villages.

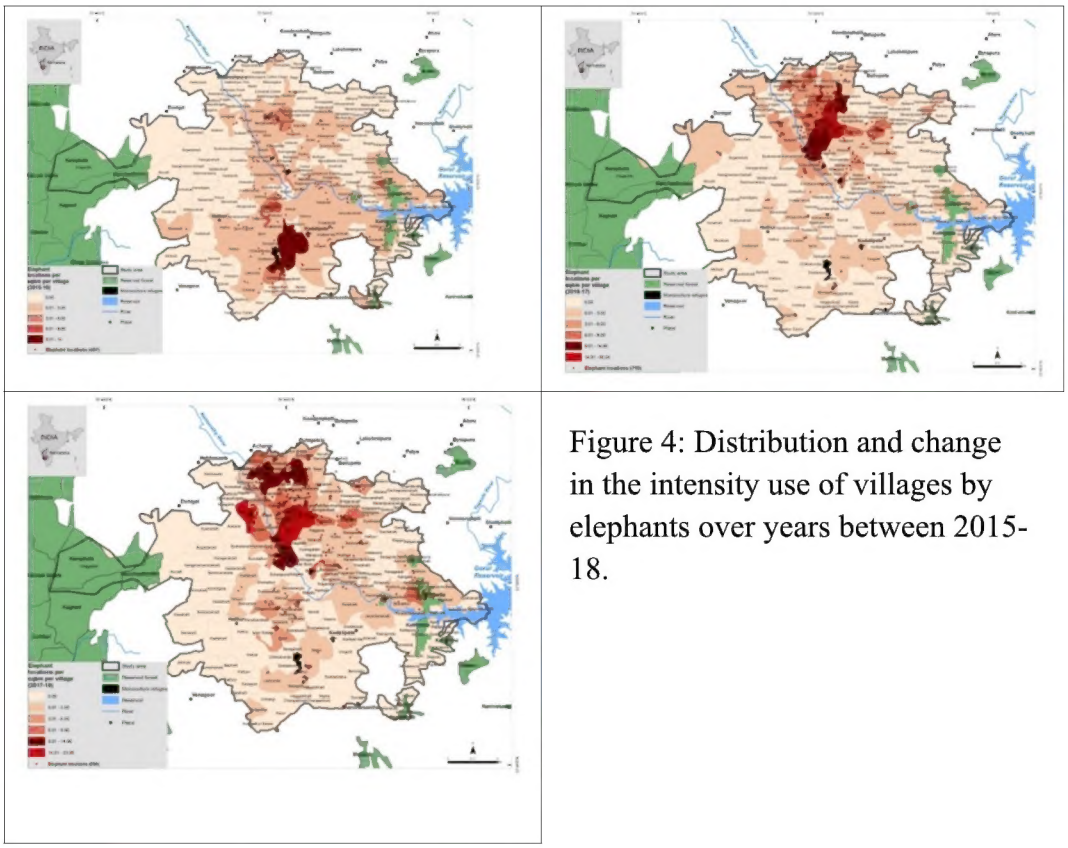

Figure 4: Distribution and change in the intensity use of villages by elephants over years between 2015-18.

2) Spatial and temporal distribution of conflicts

a) Spatial patterns of crop damage incidents

Human-elephant conflict is mainly in the form of crop damage and loss of human lives. Crop damage by elephant occurred mostly to Paddy, coffee, banana, areca, chilly, ginger,. Spatially, crop damage by elephants distributed in north to south and eastwards in the study region with varying degree of intensity of incidents across villages in the year 1. During the year 1, intensity of crop damage per unit area across villages varied from one incident/km² to 3-4 incidents/km². However, in year 2 and year 3, crop damage incidents were centered mostly around villages in northern part of the study region. A shift in elephants' use of villages to northern part in year 2 and year 3 increased intensity of crop damages per unit area across many villages in the north and north eastern partof the study region (Figure 5). Mean number of conflicts/unit area/villages increased from year 1 (0.37±0.05) to year 2 (0.79±0.19) and in year 3 (0.58±0.09) across villages.

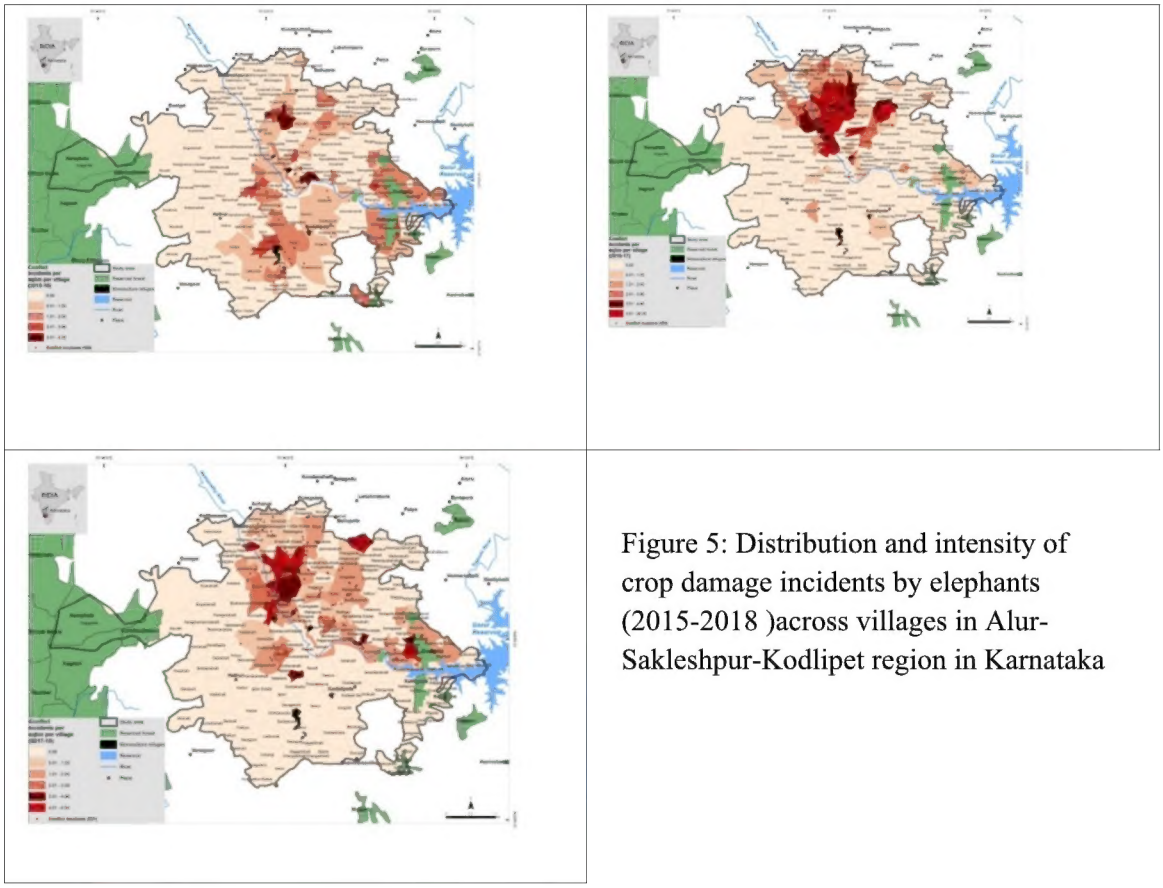

Figure 5: Distribution and intensity of crop damage incidents by elephants (2015-2018)across villages in Alur-Sakleshpur-Kodlipet region in Karnataka

b) Temporal patterns of crop damage by elephants

We have recorded 190 incidents in the year 1 (Mar 2015-Jan16) to 431 incidents in year 2 (Mar 2017-Feb 18), and 394 incidents in year 3 (Mar 2018-Feb 19). However, percentage of crop damages by elephants increased between August and January from 78% (n = 148) in year 1 to 83% (n=359) in year 2 to 91% (n=358) in year 3. However, there was a corresponding decrease in crop damage incidents between February and July (Figure 6).

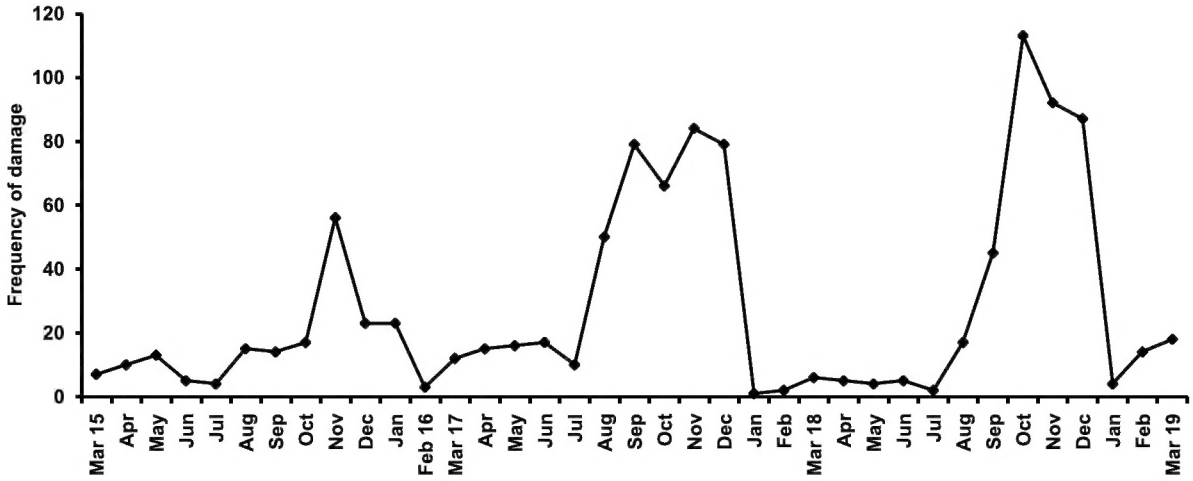

Figure 6. Temporal distribution of crop damage incidents across months between 2015-2019

c) Understanding Human fatalities due to elephants

Between 2010-19, 39 people with an average of 4 - 5 persons/year have lost lives in direct encounters with elephants in the study region. Spatially, no significant clustering of incidents noticed in the study region (Figure 7). A majority people who lost their lives were men (n=31) than women (n=8). Most human deaths incidents occurred on roads that lead to houses or working places (25 of 39 cases, 64%) and between 6 AM - 10 AM and 4PM-8PM (26 of 39 cases, 67%). A comparison of proportion of rural population with proportion of people who lost their lives in different age categories revealed that persons between 40-60 years old were more vulnerable to fatal encounters with elephants (71%, 24 of 32 cases in Hassan district alone). However, no monthly patterns observed in the occurrence of fatal incidents. An analysis of circumstances of death revealed that a majority of incidents occurred due to unexpected accidental/surprise encounters with elephants (n = 16), lack of safety at work in coffee estates/paddy fields where people were unaware of elephants (n=5), ignored warning on elephant presence (n=5), during unplanned chasing of elephants (n=5), lack of attached toilet facilities (n=3), and inebriated state of person (n=3; Figure 8).

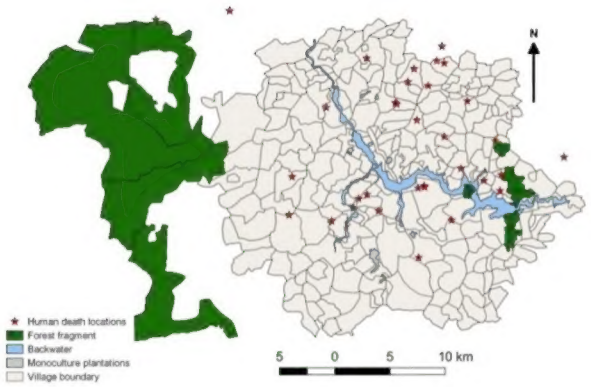

Figure 7. S incidents in Alur-Sakleshpur-Kodlipet region

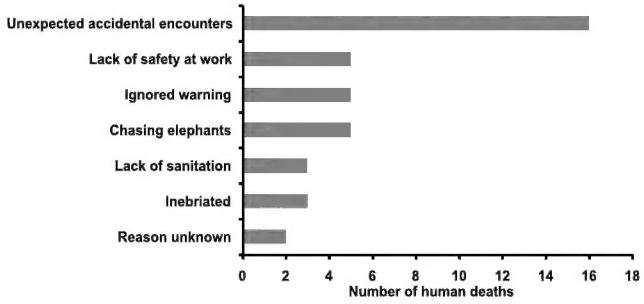

Figure 8. Circumstances of human death incidents (2015-2018) in Alur-Sakaleshpur-Kodlipet region in Karnataka

3. Efficacy and impact of Early warning systems

a) Bulk SMS text and voice call alerts

Between October 2017–March 2019, 6,02,814 text messages were sent out with an average of 1,116 messages/day. Of the total messages sent, 89% of messages were delivered (5,37,519). Of the total undelivered messages (n=65295 messages), a bulk of messages were due to operator system failure (51%, n=33,196), other reasons such as recipient's phone was not reachable (41%, n= 26,863) and recipient mobile inbox full (8%, n = 5,188) contributed to non-delivery of messages. Similarly, between February 2018 and March 2019, 2,63,177 daily voice call alerts with an average of 628 calls/day were sent out to people living within 2 km radius of the elephant locations. Of the total calls sent out 74.7% of the calls (n=1,96,681) were answered by people. Of the total number of non-delivery of calls (n=66,496), 52% of the calls (n=34488) were not answered by recipients, 36.2% of

the calls (n=24,100), the recipient's number was busy and 12% of the calls (n=7,906) were deferred to recipients.

b) GSM–based digital display boards and alert lights

Between July 2017-March 2019, digital boards displayed text messages 640 times in Kannada about elephant presence. While, alert beacons in sensitive stretches were operated 607 times indicating elephant movements within 1 km radius from each light location

c) Peoples' reception of early warning systems

From March 2015 to April 2019, a total of 6628 calls from people were received in response to SMS and call alert systems. Number of calls from people gradually increased over years, particularly after initiation of early warning systems in October 2017 (Figure 9). Of the total calls received, 53.5% (n = 3543) calls were about enquiring elephant locations, 45.1% (n = 2991) calls were about reporting elephant presence,and a small percentage of calls were about reporting crop damages (1.4% n = 94). Number of calls from people increased by 4.4 times after initiation of early warning systems in September 2017.Of the 607 alert light operations since its installation in June 2017, nearly 99%of light operations (n = 599 operations) were carried out by local communities.

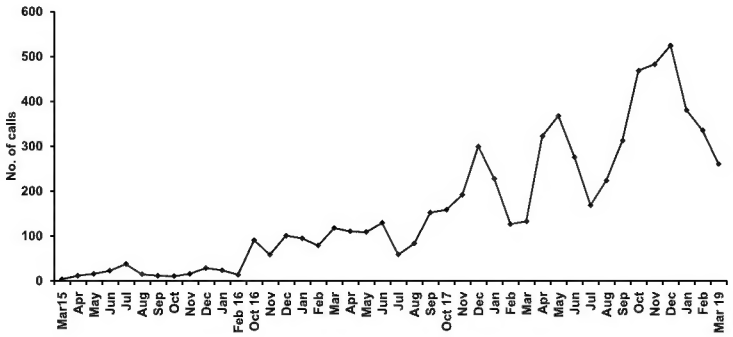

Figure 9. Distribution of phone calls received across months from people in response to SMS and call alert systems (2015-2019)

d) Impacts early warning systems and stakeholders involvement on human-elephant conflict

Incident of human death due to elephants varied across years between 2010–19(Figure ??). Human fatal incidents decreased from an average of 4.5 persons/year between 2010-2017 to two persons/year between January 2018 and July 2019. Average time take for the occurrence of human death increased from 2.6 months/year between 2010-2017 to 6.3 months/year between January 2018 - July 2019, a period of expansion and strengthening of early warning systems and pro-active steps by the state forest department and local people (Figure 10).

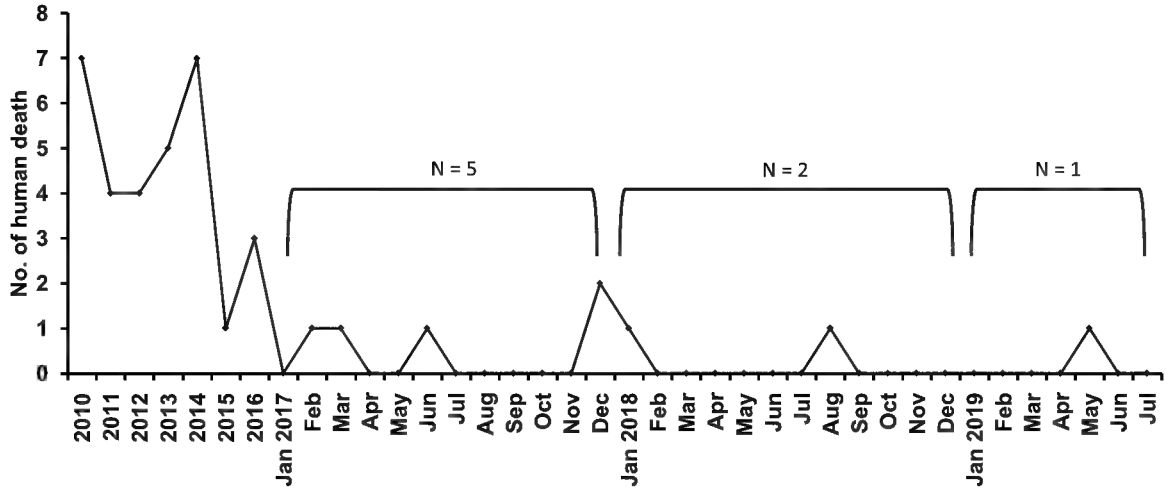

Figure 10. Distribution of human deaths across years (2010-2019)

Pro-active initiatives of the Karnataka Forest Department

The Karnataka Forest Department has initiated the following pro-active steps to mitigate conflicts and provide safety to people in the Hassan region.

a. Installation of digital display boards

An additional four digital display boards have been installed in strategic locations to convey elephant presence to people. These boards have been covering 11,800 people living in 29 villages.

b. Rapid Response Teams (RRT)

The Karnataka Forest Department in January 2018 established Rapid Response Teams (RRT), comprising of people from the local communities in the Alur, Yeslur and Sakleshpur ranges. Members of RRTs primarily track elephants and inform people in the surrounding villages and coffee estates about elephant presence.

c. Radio-collaring of elephants

Three female elephants have been radio collared by the forest department for effective tracking of the herds. Information from these collars were used by the department field staff to alert local community about elephant presence.

Discussion

Human-elephant conflict is a complex issue and conflict resolution based on effective and appropriate mitigation measures helps promote human-elephant coexistence in altered landscapes. India supports the largest Asian elephant population in Asia, but only about 16% of their range forms part of the existing PA network (Leimgruber *et al* 2003). In the rapidly declining natural forested areas due to fragmentation, wider distribution of elephants outside protected forests into anthropogenic regimes poses a greater challenge for elephant conservation and compel co-inhabitance between people and

elephants in altered landscapes (Madusudan *et al* 2015, Fernando *et al* 2019). Asian elephant being habitat generalist species, presence of forest remnants and/or monoculture refugees of acacia, Eucalyptus etc patches that provide secondary vegetation, would influence their distribution and their use of habitats in altered landscapes (Kumar *et al* 2010, Krishnan *et al* 2019).

Elephant distribution and intensity of use across villages

In the coffee-paddy dominated land-use mosaic of Hassan, elephant distribution and their intensity of use of villages varied between years. During the first year (2015-16), elephants were distributed across the landscape in a north-south and east parts of the study area, using monoculture refugees and forest fragments.. However, there was a shift in elephant distribution and intensity of use of villages in the later years with high concentration of elephant locations towards north and northeast than in the southern region of the study area. This shift was particularly influenced by the landscape changes such as clear felling of 250 acres of abandoned coffee estates which play an important role as refuges for elephants installation of heavy solar power fences around coffee estates in the central part of the study area (Krishnan *et al* 2019). Such land-use changes not only impact the use of habitats by elephants but also pushed them into neighbouring areas that may increase human-elephant conflict (Fernando *et al* 2015). In the study region, drastic shift in the intensity of use of areas by elephants across villages in the year 2 and 3, resulted in escalation of crop damage incidents in the north and northeast parts.

Human-elephant conflict

Human-elephant conflict requires a two dimensional approach as factors influencing crop/property damage and loss of human and elephant lives could be different. Hence, conflict resolution based on understanding of reasons and factors that influence these two forms of conflict is essential to arrive at locally applicable conflict mitigation measures. In the study area, crop damage by elephants were noticed in most villages with varying degrees of intensity. However, deployment of unplanned solar power fences around coffee estates and clearing of coffee estates which were abandoned for more than 10 years restricted elephants' use of monoculture refugees in the central and southern parts and intensified crop damage in villages located in the northern part of the study region during year 2 and year 3. Hence, this would require understanding of spatial use of elephants in terms of habitat use and movements and appropriate land-use planning may minimize crop damage by elephants. Temporally, crop damage incidents peaked between August - January with a corresponding decrease in other months of the year. During the past three years, a majority of crop damage incidents noticed were to paddy and coffee followed by banana, coconut etc. In the study region, paddy is grown as a subsistence crop between August and January after the onset of southwest monsoon. Lack of water resources in monoculture refugees and reserved forest patches, widely distributed agriculture ponds close to paddy fields, and availability of grass in coffee estate may have influenced crop damage

incidents. Paddy is known to attract elephants due to their high quality nutritious contents, thereby resulting in high incidence of damages to paddy (Sukumar 1990). Future studies are required to carefully investigate the influence of availability of resources such as surface water availability, extent of crop, type of crop, spatial configuration of refuge areas, behaviour of elephants etc., on the occurrence of crop damage by elephants and arrive at appropriate mechanisms to minimize conflict (Smith *et al* 2000; Sitati *et al* 2003; Wilson *et al* 2015; Chamaille'-James *et al* 2016). Majority of crop damage incidents were caused by herds than males alone in the study area unlike in many other parts where bulls are involved in high incidents of conflicts (Haturusinghe and Weerakoon, 2012). In the study region, when elephants moved out of forest fragments or monoculture refuges, it is inevitable for them to move through paddy fields which results in high incidences of damages to paddy. Nevertheless, damage to coffee bushes, banana, coconut etc in coffee estates decreased during non-paddy season (February - July) over years. Pro-active steps of minimizing driving of elephants taken by the planters when elephants were seen resting inside coffee estates and presence of rapid response teams during the day to ensure less disturbance to elephants resulted in decline in crop damage incidents in year 2 and year 3. Most of the crop damage by elephants occur at night and people were unaware of elephant incursions into paddy fields. Experimenting with temporary fences as practiced in Sri Lanka or deploying optical fences around few selected fields as these devices would warn people in advance about elephants entry around may be helpful for people to defend crops and also deflect elephants away from farm lands (Sitati *et al.* 2005; Sitati and Walpole, 2006; Hedges and Gunaryadi, 2009)

In India, an average of 400 people (more than one person per day) lose their lives annually due to elephants and 100 elephants are killed by people in retaliation (Rangarajan *et al* 2010). With increasing and spreading of human-elephant conflict during the last two decades, a minimum of 50,000 families are being affected annually (Rangarajan *et al* 2010). Loss of human life and injuries in accidental encounters with elephants cause psycho-social impacts there by increases intolerance among local people towards elephants (Jadhav and Barua 2012). In the Hassan-Kodlipet region, fatal encounters with elephants have become high priority conservation issue in human-elephant conflict resolution.Understanding circumstance of human deaths due to elephants is crucial to develop appropriate conflict mitigation measures and suggest precautionary steps to avoid direct encounters with elephants (Sitati and Ipara 2012). In the study region, a majority of people lost their lives without being aware of elephant presence and their movements. This had prompted to initiate simple, adoptable, and unique communication systems of bulk SMS and voice call alerts to people who own mobile phones and installation of GSM-based alert beacons and digital display boards in critical junction along roads help people avoid accidental encounters with elephants. Such measures in other landscapes in India have helped people to take informed decisions, resulting in decline in number of human fatal incidents and injuries, and enhances safety and positive attitude in local people towards elephants (Kumar and Raghunathan 2014). Instances of human deaths due to elephants, restrictions on

movement of people, fatigue due to guarding property, poor attendance of school as a result of loss of sleep or fear of travel etc., erode tolerance levels of people and negatively affect elephant conservation efforts (Hoare 2001, Madhusudan 2003, Nelson *et al* 2003). In many places, children and adults need to walk long distances using roads and trails on daily basis. Lack of visibility through coffee bushes, winding roads, locating elephants would become extremely difficult particularly during early mornings and late in the evening. Provision of transport system during critical times between 7 - 9 AM and 4-8 PM and installation of street lights in certain stretches of roads should be taken by the concerned government departments. Pro-active steps may be initiated by the state forest department to convey a meeting with other government departments, local people, and researchers to identify sensitive areas of use by elephants to develop appropriate mechanisms to avoid potential risk of encountering elephants and facilitate increased safety to people.

Early warning systems

In the study region, collective efforts of people, forest department, and conservation organisations helped in developing sustainable elephant information network to communicate about elephant locations. Most of the messages and call alerts have been delivered or attended by people indicate that bulk messages and calls in Kannada language have been positively received by people which is apparent from the significant increase in that number of calls received from people over years, particularly after initiation of early warning systems in October 2017.

Involvement of stakeholders in the management of human-wildlife conflict is crucial for conflict resolution (Osborn and Parker 2003, Treves *et al* 2009, Bal *et al* 2012). Elephant alert indicators installed in eight locations were useful in communicating about elephant presence within 1 km radius from each of light when they were operated by identified people. These mobile operated indicators were also useful for people who failed to read text messages or unable to receive calls or do not own a mobile phone. Sustained active participation by local community in the use of elephant alert indicators is evident from the results that operation of indicators by people remained high (an average of 99%). This also signifies the positive impact of the measures, seriousness and responsibility of people to convey elephant presence to others in respective localities, and non-dependency of people over conservation organizations and concerned authorities to safeguard their lives and property.

Impact of early warning systems and proactive initiatives

Human deaths due to elephants varied across years between 2010-2019. Large scale capture and removal of elephants was conducted in 2013 and 2014 and soon after these captures, there was one incident of human death. But human death incidents increased in the later years of 2016 and 2017 after recolonization of elephants in 2015. This clearly indicates that capture of elephants as a measure of human-elephant conflict mitigation may not reduce human fatal incidents. However, later in 2017

and 2018, collective efforts involving Rapid Response Teams of the Forest Department and local people coupled with implementation of early alert systems had positive impacts on human-elephant conflict mitigation in the following ways.

1. There was a decline in number of human death incidents after initiation of early warning systems.
2. Average number of people losing lives declined from 4 - 5 persons/year between 2010-2017 to two persons per year between 2018 and until July 2019.
3. Average time taken between two human death incidents increased from two and half months between 2010-17 to nearly six and half months between 2018-19.
4. Adopting a '*no drive*' strategy by coffee planters when elephants were seen inside coffee estates resulted in gradual decline in crop damage to coffee over years.
5. Bulk SMS and voice call systems helped planters to take informed decisions such as allocation of work to safe areas within an estate thereby providing safety to workers.
6. Early alert message systems and timely presence of Rapid Response Teams helped instill increased safety in people and helped in avoiding the potential risk of encountering elephants.
7. Alert systems also helped people to plan their outdoor activities.

Conclusions

Collective efforts by stakeholders along with the introduction of early warning systems and proactive measures by the forest department has made Hassan-Kodlipet region as a model landscape for rest of the human-elephant conflict areas in India. The following are the salient features from this study.

1. In habitat mosaics such as the Hassan-Kodlipet region, it is inevitable for people and elephants to share spaces. Hence measures that aim at conflict reduction, safety to people and elephant lives, and minimizing damages to crops would enhance human-elephant co-inhabitance.

2. Early warning systems about elephants, timely action by Karnataka Forest Department field staff, and participation of local people resulted in decline in human death incidents.

3. Better management practices adopted by coffee planters and presence of RRTs have minimized damages in coffee estates.

4. Early warning initiatives have been positively received by people which enhance increased safety to peoples' lives and help in effective management of conflict situation.

5. Active involvement by local people, and forest department personnel in conflict mitigation measures and sharing responsibility of managing conflicts is a way forward towards human-

elephant coexistence. Willingness to continue collective efforts by stakeholders would make these measures sustainable and decrease the burden on any single/fewer agencies.

Recommendations

The study recommends the following steps that may be adopted to mitigate conflict in the Alur-Sakleshpur-Kodlipet region.

1. Presence of monoculture refuges and forest fragments in the study region have been critical for elephants while moving through the landscape. Hence, there is a need to retain and protect these patches, as they provide food and shelter for elephants and help in minimizing conflicts.
2. Continuation of early warning systems has been essential as these facilities helped people to take informed decision to avoid direct encounters with elephants and resulted in reducing human death incidents in the study region.
3. There is a need to strengthen and expansion of early warning systems to cover additional villages as few of the human fatal incidents occurred beyond the current 220 villages in the study region.
4. Experimenting with elephant detection systems using optical fences/sensor based detectors around certain high conflict prone paddy farms as early warning to farmers coupled with coordinated efforts between local community and forest department field staff help reduce crop damage by elephants.
5. Installation of temporary solar power fences around paddy fields with community guarding may help reduce crop damages as implemented in Sri Lanka.
6. Pro-active steps are required to engage with other government departments to provide transportation and street light facilities in sensitive areas of use by elephants.
7. Presence of solar power fences and installation of new barriers around coffee estates have been detrimental for free movement of elephants besides resulting in increased crop damage by elephants. Presence of power fences on either sides of road may force elephants to use roads and residential places frequently which may endanger people lives in direct encounters. Hence, efforts should be made to discourage fencing of large areas and promote creation of openings at regular crossing points. This would facilitate elephant movements without them coming into contact people on roads thereby reducing possible direct encounters with elephants.
8. Since, capture and removal of elephants had no impact in reducing human death incidents. such reactive measures should not be seen as a measure of conflict mitigation .
9. In addition to existing radio collars on few female elephants in herds, collaring of solitary males may help effective tracking of individuals and enhance safety to people using early warnings.

10. Awareness and sensitization programmes to convey people about the steps required to be taken while moving through elephant presence areas would further reduce incidents of fatalities.
11. Periodic meetings among forest department officials, planters and researchers would help enhance appropriate pro-active steps to deal with human-elephant conflict situation.
12. Since, paddy is grown as a subsistence annual crop by majority of farmers, experimenting with technological interventions such as installation of optical fences around few selected paddy fields as an early warning to farmers may help reduce crop damage by elephants.
13. Rapid Response Teams need to be strengthened with adequate facilities such as four-wheel vehicle, field gear etc., and training in tracking and crowd management techniques.

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ACKNOWLEDGEMENTS

We sincerely thank the Karnataka Forest Department for permissions and cooperation to carry out the project. We would like to thank Elephant Family, UK, Whitley Fund for Nature, UK, Nilekani Philanthropies and Oracle for providing financial support to the project. Many forest officers, particularly Mr. A. K. Singh, Chief Conservator of Forests, Hassan circle, Mr. Ganesh S. Bhat, IFS, Divisional Forest Officer, Hassan, Mr. M.L.Manjunath, SFS, Divisional Forest Officer, Hassan Circle, Mr.M.Sivaram Babu, IFS, Mr. Manoj Kumar, IFS, Chief Conservator of Forests, Madikeri Circle, Assistant Conservators of Forests, Mr. Ravindra, Mr. Ramesh Babu, Mr.Harish and Mr.Lingaraju, Range Forest Officers, Mr. Sudarshan, Mr. Hemanth Kumar, Mr. M.M. Acchappa, Mr. H. K. Mariswamy, Mr.Ravindra and Mr.Rajappa and for their cooperation and sharing information. We acknowledge the support of the Forest Department field staff in Alur and Kodlipet regions for the project activities. We also thank the Grama Panchayats of Mallapura, Kargodu, Yeslur, and Kodlipet and Hassan District Planters Association (HDPA) for their help and facilitating interactions with members and the public, and the planters and local farmers of Alur and Kodlipet, who have helped and cooperated with the team. Niagara Automations, Coimbatore and Ktron Systems, Bangalore for their technical support. We acknowledge the help of R. Raghunath with mapping and support from colleagues at NCF.